Alternative Fuel Transit Bus Evaluation Program

Transit buses represent one of the best applications for alternative fuels, which have made significant inroads into the transit bus market. As of January 1996, approximately 4% of the more than 50,000 transit buses in the United States surveyed by the American Public Transit Association ran on an alternative fuel such as ethanol, methanol, compressed natural gas (CNG), or liquefied petroleum gas (LPG). Even more significant, 1 out of every 5 new buses on order is an alternative fuel bus. These numbers do not include electric trolley buses.

The National Renewable Energy Laboratory, with funding from the U.S. Department of Energy, initiated a program to study the performance, reliability, costs, and emissions of alternative fuel transit buses versus conventional diesel buses (controls). The program involved collecting detailed operational and maintenance data from more than 100 buses at eight transit agencies across the country. A program goal was to have 10 test buses of each alternative fuel type, with 10 controls, split between two agencies, operating for 18 months. West Virginia University used its transportable chassis dynamometer to measure the emissions from the buses using a Central Business District (CBD) driving cycle.

Transit properties involved in the program, and their alternative fuel buses, were:

- Houston Metro, in Houston, Texas (10 liquefied natural gas [LNG] buses with Detroit Diesel 6V92 Pilot Injection Natural Gas engines)
- Tri-Met, in Portland, Oregon (eight LNG buses with Cummins L10 dedicated spark-ignited engines)
- Metro Dade, in Miami, Florida (five methanol buses with Detroit Diesel 6V92 engines and five CNG buses with Cummins L10 engines)
- Triboro in New York, New York (five methanol buses with Detroit Diesel 6V92 engines, and five CNG buses with Cummins L10 engines)
- Pierce Transit in Tacoma, Washington (10 CNG buses with Cummins L10 engines)
- Metropolitan Transit Commission, Minneapolis/St. Paul, Minnesota (five ethanol buses with Detroit Diesel 6V92 engines)
- Greater Peoria Transit in Peoria, Illinois (five ethanol buses with Detroit Diesel 6V92 engines)
- Bi-State in St. Louis, Missouri (five 20% biodiesel blend buses with Detroit Diesel 6V92 engines)

The alternative fuel engines in this program have only a few years of product development, versus decades for the diesel engine; however, the results show they are competing very well with diesels in many areas:

- *Vehicle Reliability.* Road calls experienced per 1,000 miles of operation constitute one measure of a bus's reliability. A road call is defined as any event that prevents a driver from completing his or her route and results in a call for a backup bus. The program studied total road calls and those attributable to engine/fuel system related components only—the areas most likely to be affected by alternative fuel use. The number of engine/fuel system-related road calls for the Tacoma CNG buses is the same as for the diesel buses. Most other sites show some reliability penalty, but in many cases the causes are either relatively minor (the buses running out of fuel because of driver unfamiliarity with the vehicle), or appear solvable (fuel filter plugging because of fuel quality problems at the alcohol sites).

- *Operating Costs.* Operating costs of the buses are largely driven by the fuel cost. Fuel cost differences versus diesel far outweigh any differences in maintenance costs between the alternative fuel and diesel buses. Operating costs are lowest for the CNG buses, which are approximately equal to diesel bus operating costs. Operating costs are the highest for the alcohol and biodiesel buses because of high fuel prices.

- *Capital Costs.* Capital costs consist of the extra cost to purchase an alternative fuel bus, and the extra cost (if any) to modify the facilities to fuel, service, and maintain them. Capital costs are the highest for CNG and LNG buses, and lowest for the alcohol and biodiesel buses—inverse to the operating costs. In the future, alternative fuel engine prices are expected to decrease as volumes increase, although whether they will be equal to or lower than diesel is unclear.

  At the present time, no alternative fuel combines a low operating cost with a low up-front capital cost.

- *Vehicle Emissions.* Emissions were measured on a transportable chassis dynamometer using the CBD driving cycle.

  Natural gas and alcohol buses have the potential to significantly lower particulate matter (PM) and oxides of nitrogen (NO_x) emissions. With natural gas, PM emissions are virtually eliminated. This is particularly important because the federal emissions standards for PM and NO_x are becoming more stringent, and PM is becoming increasingly implicated in health effects on humans.

  Test results also showed high variability in the emissions results from the alternative fuel vehicles. This probably results from the relative immaturity of the technology and from inadequate vehicle maintenance. Investigative emissions testing showed substantial reductions in high-emitting vehicles after tune-ups and parts replacements. Also, newer generation CNG engines feature closed-loop feedback control of air:fuel ratio, which should significantly reduce variability between engines.

Newer, significantly more advanced alternative fuel engines than those in this program have already been introduced, and they promise even better performance.

Reports from the Program

Several reports are now or will soon be available on the final results from this program. The final report that summarizes the results from the program is "Alternative Fuel Transit Buses," and a brochure is available that focuses on Pierce Transit in Tacoma, Washington, "The Pierce Transit Success Story..." A final technical report is planned to be ready by the end of October, 1996, which is titled "Alternative Fuel Transit Bus Evaluation Results."

Future Activities

There are a few areas that still need work. The largest activity is in the area of more emissions testing of newer alternative fuel engine technologies including the Cummins L10-280G/300G, C8.3G, and M11G; Detroit Diesel Corporation Series 50G, Series 50P (if this engine goes into production), and Series 60G. Some investigation and reporting activities will be accomplished to document the progress of the Series 50 propane engine program in transit. The other activity is finding a newer technology liquefied natural gas site that uses the newer on-board fuel tanks (without cryogenic pumps) and newer refueling station equipment.